U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

11.3 GASEOUS WASTE MANAGEMENT SYSTEMS

REVIEW RESPONSIBILITIES

Primary - Effluent Treatment Systems Branch (ETSB)

Secondary - Radiological Assessment Branch (RAB)

I. AREAS OF REVIEW

At the construction permit (CP) stage of review, ETSB reviews the information in the applicant's safety analysis report (SAR) in the specific areas that follow. At the operating license (OL) stage of review, ETSB review consists of confirming the design accepted at the CP stage and evaluating the adequacy of the applicant's technical specifications in these areas. The ETSB review includes:

1. The gaseous waste management (treatment and ventilation) systems design, design objectives, design criteria, methods of treatment, expected releases, and principal parameters used in calculating the releases of radioactive materials (noble gases, radioiodine, and particulates) in gaseous effluents. The ETSB review will include the system piping and instrumentation diagrams (P&IDs), and the process flow diagrams showing methods of operation and factors that influence waste treatment, e.g., system interfaces and potential bypass routes.

2. Equipment and ventilation system design capacities, expected flows and radionuclide concentrations, expected decontamination factors for radionuclides, and available holdup time. The system design capacity relative to the design and expected input flows, the period of time the system is required to be in service to process normal waste flows, availability of standby equipment, alternate processing routes, and interconnections between subsystems. This information is used to evaluate the overall system capability to meet anticipated demands imposed by major processing equipment downtime and waste volume surges due to anticipated operational occurrences.

3. The quality group classifications of piping and equipment, and the bases governing the design criteria chosen. Design and expected temperatures and pressures, and materials of construction of the components of the system.

4. Design provisions incorporated in the equipment and facility design to facilitate operation and maintenance in conformance with the guidelines of Regulatory Guide 1.143. (Ref. 8)

5. Special design features to reduce leakage of gaseous waste or discharge of radioactive material in gaseous effluents. Special design features, topical reports incorporated by reference, and data obtained from previous experience with similar systems which are submitted with the SAR.

6. Design features to preclude the possibility of an explosion if the potential for explosive mixtures exist.

Design provisions incorporated to sample and monitor radioactive materials in gaseous process and effluent streams are reviewed under SRP Section 11.5 by ETSB.

A secondary review is performed by the Radiological Assessment Branch (RAB). RAB calculates the doses based on the gaseous source term provided by ETSB and transmits the results to ETSB for their use in evaluating the gaseous waste management systems. RAB also reviews the dose calculational portions of the radiological effluent technical specifications for input into SRP Section 16.0.

In addition, ETSB will coordinate other branches' evaluations that interface with the overall review of the system as follows: the Structural Engineering Branch (SEB) determines the acceptability of the design analyses, procedures, and criteria used to establish the ability of seismic Category I structures housing the systems and supporting systems to withstand the effects of natural phenomena such as the safe shutdown earthquake (SSE), probable maximum flood (PMF), and tornado missiles as part of its primary review responsibility for SRP Sections 3.3.1, 3.3.2, 3.5.3, 3.7.1 through 3.7.4, 3.8.4, and 3.8.5. Upon request from ETSB, the SEB will also review non-seismic Category I structures housing radwaste management systems to determine their ability to withstand the effects of the Operating Basis Earthquake (OBE) in accordance with Regulatory Guide 1.143. The Mechanical Engineering Branch (MEB) determines the acceptability of the seismic and quality group classifications for structures and system components as part of its primary review responsibility for SRP Sections 3.2.1 and 3.2.2. The reviews for Technical Specifications and Quality Assurance are coordinated and performed by the Licensing Guidance Branch and the Quality Assurance Branch (QAB) as part of their primary review responsibility for SRP Sections 16.0 and 17.0, respectively.

For those areas of review identified above as being reviewed as part of the primary review responsibility of other branches, the acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP section of the corresponding primary branch.

II. ACCEPTANCE CRITERIA

A. ETSB acceptance criteria are based on meeting the relevant requirements of the following regulations:

1. 10 CFR Part 20, §20.106, as it relates to radioactivity in effluents to unrestricted areas.

2. 10 CFR Part 50, §50.34a, as it relates to sufficient design information being provided to demonstrate that design objectives for equipment necessary to control releases of radioactive efffluents to the environment have been met.

3. General Design Criterion 3 as it relates to providing protection to gaseous waste handling and treatment systems from the effects of an explosive mixture of hydrogen and oxygen.

4. General Design Criterion 60 as it relates to the radioactive waste management systems being designed to control releases of radioactive materials to the environment.

5. General Design Criterion 61 as it relates to radioactivity control in gaseous waste management systems and ventilation systems associated with fuel storage and handling areas.

6. 10 CFR Part 50 Appendix I, Sections II.B., II.C., and II.D., as it relates to the numerical guides for design objectives and limiting conditions for operation to meet the "as low as is reasonably achievable" criterion.

   The requirements of the Commission regulations identified above are met by using the regulatory positions contained in the following regulatory guides:

   a. Regulatory Guide 1.140 as it relates to the design testing and maintenance of normal ventilation exhaust systems at nuclear power plants.

   b. Regulatory Guide 1.143 as it relates to the seismic design and quality group classification of components used in the gaseous waste treatment system and structures housing the systems and the provisions used to control leakages.

B. Specific criteria necessary to meet the relevant requirements of the Commission regulations are as follows:

1. The gaseous waste management systems should have the capability to meet the dose design objectives and include provisions to treat gaseous radioactive wastes such that:

   a. The calculated annual total quantity of all radioactive material released from each reactor at the site to the atmosphere will not result in an estimated annual external dose from gaseous effluents to any individual in unrestricted areas in excess of 5 millirems to the total body or 15 millirems to the skin.

   b. The calculated annual total quantity of all radioactive iodine and radioactive material in particulate form released from each reactor at the site in effluents to the atmosphere will not result in an estimated annual dose or dose commitment from such radioactive iodine and radioactive material in particulate form for any individual in an unrestricted area from all pathways of exposure in excess of 15 millirems to any organ.

c. In addition to a. and b., above, the gaseous waste management systems should include all items of reasonably demonstrated technology that when added to the system sequentially and in order of diminishing cost-benefit return, can for a favorable cost-benefit ratio effect reductions in dose to the population reasonably expected to be within 50 miles of the reactor.

d. The concentrations of radioactive materials in gaseous effluents released to an unrestricted area should not exceed the limits specified in 10 CFR Part 20, Appendix B, Table II, Column 1.

2. The gaseous waste management system should be designed to meet the anticipated processing requirements of the plant. Adequate capacity should be provided to process gaseous wastes during periods when major processing equipment may be down for maintenance (single failures) and during periods of excessive waste generation. ETSB will accept systems that have adequate capacity to process the anticipated wastes and that are capable of operating within the design objectives during normal operation, including anticipated operational occurrences. To meet these processing demands, ETSB will consider shared systems, redundant equipment, and reserve storage capacity.

3. The seismic design and quality group classification of components used in the gaseous waste management systems and structures housing these systems should conform to the guidelines of Regulatory Guide 1.143. The design should include precautions to stop continuous leakage paths, i.e., to provide liquid seals downstream of rupture discs and to prevent permanent loss of the liquid seals in the event of an explosion.

4. ETSB will accept system designs that contain provisions to control leakage and to facilitate operation and maintenance in accordance with the guidelines of Regulatory Guide 1.143.

5. ETSB will use the guidelines in Regulatory Guide 1.140 (Ref. 9) for the design, testing and maintenance of HEPA filters and charcoal adsorbers installed in normal ventilation exhaust systems.

   If decontamination factors for iodine different from those specified in Regulatory Guide 1.140 are used for design purposes, they should be supported by test data under operating or simulated operating conditions (temperature, pressure, humidity, expected iodine concentrations, and flow rate). The effects of aging and poisoning by airborne contaminants should also be supported by test data.

6. If the potential for an explosive mixture of hydrogen and oxygen exists, the gaseous waste management systems should either be designed to withstand the effects of a hydrogen explosion, or be provided with dual gas analyzers with automatic control functions to preclude the formation or buildup of explosive mixtures.

a. For a system designed to withstand the effects of a hydrogen explosion, the design pressure of the system should be approximately 20 times the operating absolute pressure (including the intermediate stage condenser for BWR offgas systems).

Small allowances should be made to conform to standard design pressures for off-the-shelf components; i.e., if the system operating pressure is nominally 15 psia but could approach 20 psia by design, piping could be designed to 350 psia, since the next higher standard pressure rating is 600 psia.

The process gas stream should be analyzed for potentially-explosive mixtures and annunciated both locally and in the control room.

b. For systems not designed to withstand a hydrogen explosion, dual gas analyzers (with dual being defined as two independent gas analyzers continuously operating and providing two independent measurements verifying that hydrogen and/or oxygen are not present in potentially-explosive concentrations) with automatic control functions are required to preclude the formation or buildup of explosive hydrogen/ oxygen mixtures. Gas analyzers should annunciate alarms both locally and in the control room. "High alarm" should be set approximately 2% and "High-high alarm" should be set at a maximum of 4% hydrogen or oxygen.

Control features to reduce potential for explosion should be automatically initiated at "High-high alarm" setting. The automatic control features should be as follows: (1) for systems designed to preclude explosions by maintaining either hydrogen or oxygen below 4%, the source of hydrogen or oxygen (as appropriate) should be automatically isolated from the system (valve should fail in closed position); (2) for systems using recombiners, if the downstream hydrogen and/or oxygen concentration exceeds 4% (as appropriate), acceptable control features include automatically switching to an alternate recombiner train; and (3) injection of diluents to reduce concentrations below the limits specified herein.

Systems designed to operate below 4% hydrogen and below 4% oxygen may be analyzed for either hydrogen or oxygen; systems designed to operate below 4% hydrogen only (no oxygen restrictions), should be analyzed for hydrogen; and systems designed to operate above 4% hydrogen, should be analyzed for oxygen.

For BWR systems with steam dilution upstream of the recombiners, analysis for hydrogen (oxygen is not an acceptable alternative) should be downstream of the recombiners and upstream of the delay portions of the system (analysis upstream of the recombiners is not required if the system is designed to assure the availability of dilution steam during operation). For PWR systems using recombiners, analysis for hydrogen and/or oxygen should be downstream of the recombiners. In addition, unless the system design features preclude explosive mixtures of hydrogen and oxygen upstream of the recombiners, analysis for hydrogen and/or oxygen (as appropriate) should be upstream of the recombiners as well. The number of gas analyzers and control features at each location should be in accordance with this SRP section. One gas analyzer upstream and one gas analyzer downstream of the recombiners should not be construed as dual gas analyzers. For systems involving pressurized storage tanks (excluding surge tanks), at least one gas analyzer is required between the compressor and the storage tanks. Dual gas analyzers set to sequentially measure concentrations both upstream and downstream of a recombiner are acceptable for a PWR. When two or more potentially explosive process streams are combined before entering a component, each stream or the combination thereof, is required to have dual gas analyzers.

If gas analyzers are to be used to sequentially measure several points in a system not designed to withstand a hydrogen explosion, at least one gas analyzer which is continuously on stream is required. The continuous gas analyzer should be at a point common to streams measured sequentially; i.e., should be sampling the combined stream.

Gas analyzers should have daily sensor checks, monthly functional checks and quarterly calibrations.

Gas analyzers installed in systems designed to withstand a hydrogen explosion should also be capable of withstanding a hydrogen explosion; gas analyzers installed in the systems not designed to withstand a hydrogen explosion need not be capable of withstanding a hydrogen explosion (similar requirements apply to radiation monitors which are internal to lines containing potentially explosive mixtures).

All gas analyzers shall be nonsparking.

III. REVIEW PROCEDURES

The reviewer will select and emphasize material from this SRP section, as may be appropriate for a particular case.

1. In the ETSB review of the gaseous waste management systems, the P&IDs and system process flow diagrams are reviewed to determine all sources of gaseous waste, the points of collection of gaseous wastes, the flow paths of gases through the systems, including all bypasses, the treatment provided and the points of release of gaseous effluents to the environment. This information is used to calculate the quantity of radioactive material (noble gases, radioiodine, and particulates) released annually in gaseous effluents during normal operations, including anticipated operational occurrences, using the given parameters, the GALE Code, and the calculational techniques given in NUREG Reports 0016 and 0017. A complete Fortran listing of the GALE computer code is given in these reports. The results of this calculation will be used to determine whether the proposed gaseous waste management systems design meets the acceptance criterion of subsection II.B.1.d of this SRP section. Compliance with the acceptance criteria of subsection II.B.1.a and b of this SRP section concerning exposures of the total body, skin, and thyroid will be determined based on RAB dose calculations using the ETSB calculated source term. Conformance with the acceptance criterion given in subsection II.B.1.c of this SRP section concerning the cost-benefit analysis will be determined based on RAB man-rem dose calculations in conjunction with ETSB cost-benefit studies.

2. The ETSB review of the gaseous waste management systems design capacity will encompass two major areas:

   a. The capability of the system to process gaseous wastes in the event of a single major equipment item failure. For nonredundant equipment or components, ETSB will assume a 3-week downtime every other year (10 days per year average).

   b. The capability of the system to process gaseous wastes at design basis fission product levels, i.e., from 1% of the fuel producing power in a PWR or, in a BWR, consistent with a noble gas release rate of 100 μCi/sec/MWt at 30 minutes delay.

   ETSB will review the operational flexibilities designed into the system, e.g., cross connections between subsystems, redundant or reserve processing equipment, and reserve storage capacity.

   In the evaluation of charcoal delay systems for radioactive gas decay, ETSB considers the bed dimensions, mass of charcoal, flow rate, temperatures, pressures, humidity, and dynamic adsorption coefficients to calculate the effective holdup times.

3. ETSB compares the quality group classification of piping and equipment in the gaseous waste management systems with the guidelines of Regulatory Guide 1.143. ETSB also compares the seismic design criteria of equipment and of structures housing the gaseous waste management systems with the design guidance identified in Regulatory Guide 1.143. The exceptions are transmitted to MEB, which has primary responsibility under SRP Sections 3.2.1 and 3.2.2 and to SEB, which has primary responsibility under SRP Sections 3.3.1, 3.3.2, 3.5.3, 3.7.1, 3.7.2, 3.7.3, 3.7.4, 3.8.4, and 3.8.5. ETSB also determines if the applicant's design includes adequate provisions to stop continuous leakage paths after an explosion. The areas of concern are (1) streams where water decomposition gases (hydrogen and oxygen) exist in a BWR, (2) cover gas streams where air inleakage can occur in a PWR, and (3) where there is a possibility of liquid hydrocarbons and ozone collecting in a cryogenic distillation system.

4. ETSB will compare the system design, system layout, equipment design, method of operation, and provisions to reduce leakage and to facilitate operations and maintenance to the guidelines of Regulatory Guide 1.143. ETSB will evaluate special design features provided to control leakage from system components and topical reports on system designs on a case-by-case basis.

5. ETSB will compare the design, testing and maintenance criteria for HEPA filters and charcoal adsorbers in filtration systems with the guidelines of Regulatory Guide 1.140.

6. If there is a potential that explosive hydrogen/oxygen mixtures exist, ETSB will determine, using the system description and P&IDs, whether the applicant has designed the gaseous waste management systems to withstand the effects of such an explosion, or has provided the required dual instrumentation to annunciate and prevent the buildup of potentially explosive mixtures.

7. At the OL stage ETSB will review the technical specifications proposed by the applicant for process and effluent control for input into SRP Section 16.0. The reviewer will determine that the content and intent of the technical specifications prepared by the applicant are in agreement with the requirements developed as a result of the staff's review. The review will include the evaluation or development of appropriate limiting conditions for operation and their bases consistent with the plant design and the requirement of 10 CFR Part 50, §50.36a.

8. ETSB reviews the quality assurance provisions for the gaseous waste management systems in accordance with Regulatory Guide 1.143. The exceptions are transmitted to QAB, which has the primary responsibility under SRP Sections 17.1 and 17.2.

IV. EVALUATION FINDINGS

ETSB verifies that sufficient information has been provided and that the review is adequate to support conclusions of the following type, to be included in the staff's safety evaluation report:

> The staff concludes that the design of the gaseous waste management systems is acceptable and meets the requirements of 10 CFR Part 20, §20.106, 10 CFR Part 50, §50.34a, General Design Criteria 3, 60, and 61, and 10 CFR Part 50 Appendix I. This conclusion is based on the following:
>
> 1. The applicant has met the requirements of GDC 60 and 61 with respect to controlling releases of radioactive material to the environment by assuring that the design of the gaseous waste management systems include the equipment and instruments necessary to detect and to control the release of radioactive materials in gaseous effluents.
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> 2. The applicant has met the requirements of Appendix I of 10 CFR Part 50 by meeting "as low as is reasonably achievable" criterion as follows:
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>   a. Regarding Sections II.B and II.C of Appendix I we have considered releases of radioactive material (noble gases, radioiodine and particulates) in gaseous effluents for normal operation including anticipated operational occurrences based on expected radwaste inputs over the life of the plant for each reactor on the (______ _________) site. We have determined that the proposed gaseous waste management systems are capable of maintaining releases of radioactive materials in gaseous effluents such that the calculated individual doses in an unrestricted area from all pathways of exposure are less than 5 mrem to the total body or 15 mrem to the skin and less than 15 mrem to any organ from releases of radioiodine and radioactive material in particulate form.
>
>   b. Regarding Section II.D of Appendix I we have considered the potential effectiveness of augmenting the proposed gaseous waste management systems using items of reasonably demonstrated technology and have determined that further effluent treatment will not effect reductions in the cumulative population dose within a 50-mile radius of the reactor at a cost of less than $1,000 per man-rem or $1,000 per man-thyroid-rem.

3. The applicant has met the requirements of 10 CFR Part 20 since we have considered the potential consequences resulting from reactor operation with "1% of the operating fission product inventory in the core being released to the primary coolant" for a PWR or "a fission product release rate consistent with a noble gas release rate to the reactor coolant of 100 μCi/MWt-sec at 30 minutes decay" for a BWR and determined that under these conditions, the concentrations of radioactive materials in gaseous effluents in unrestricted areas will be a small fraction of the limits specified in 10 CFR Part 20, Appendix B, Table II, column 1.

4. We have considered the capabilities of the proposed gaseous waste management systems to meet the anticipated demands of the plant due to anticipated operational occurrences and have concluded that the system capacity and design flexibility are adequate to meet the anticipated needs of the plant.

5. We have reviewed the applicant's quality assurance provisions for the gaseous waste management systems, the quality group classifications used for systems components, the seismic design applied to the design of the systems, and of structures housing the radwaste systems. The design of the system and structures housing these systems meet the criteria as set forth in Regulatory Guide 1.143.

6. We have reviewed the provisions incorporated in the applicant's design to control releases due to hydrogen explosions in the gaseous waste management systems and concluded that the measures proposed by the applicant are adequate to prevent the occurrence of an explosion or to withstand the effects of an explosion in accordance with General Design Criterion 3 of Appendix A to 10 CFR Part 50.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licenses regarding the NRC staff's plans for using this SRP section.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides and NUREGs.

VI. REFERENCES

1. 10 CFR Part 20, "Standards for Protection Against Radiation."

2. 10 CFR Part 50, §50.34a, "Design Objective for Equipment to Control Releases of Radioactive Materials in Effluents - Nuclear Power Reactors."

3. 10 CFR Part 50, §50.36a, "Technical Specifications on Effluents from Nuclear Power Reactors."

4. 10 CFR Part 50, Appendix A, General Design Criterion 3, "Fire Protection," General Design Criterion 60," Control of Releases of Radioactive Materials to the Environment," and General Design Criterion 61 "Fuel Storage and Handling and Radioactivity Control."

5. 10 CFR Part 50, Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low As Is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents."

6. NUREG-0017, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWRs)."

7. NUREG-0016, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Boiling Water Reactors (BWRs)."

8. Regulatory Guide 1.143, "Design Guidance for Radioactive Waste Management Systems, Structures and Components in Light-Water-Cooled Nuclear Reactor Power Plants."

9. Regulatory Guide 1.140, "Design, Testing and Maintenance Criteria for Normal Ventilation Exhaust System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants."

BRANCH TECHNICAL POSITION ETSB 11-5

Postulated Radioactive Releases Due to a Waste Gas System Leak or Failure

A. BACKGROUND

During normal operation of a nuclear power plant, radioactive fission and activation gases and gases that are the result of radiolytic decomposition of water are generated in the reactor and are continuously removed from the reactor coolant. After separation, the gases may be treated for volume reduction of the nonradioactive species before the radioactive gases are stored for radioactive decay prior to release to the environment. The system to accomplish this separation, reduction, and decay process is called the waste gas system.

The waste gas system at BWRs may include steam air ejectors, vacuum pumps, decay pipes, moisture separators, condensers, cryogenic distillation, tanks, ambient or chilled charcoal adsorbers, filters, process sampling, instrumentation and radiation monitoring, and control features. The waste gas system at PWRs may include volume control tank, letdown or shim bleed gas separation, gas stripping, cover gas collection, compressors, recombiners, surge and storage tanks, ambient or chilled charcoal adsorbers, moisture separators, condensers, filters, process sampling, instrumentation and radiation monitoring, and control features. In all cases, the waste gas system is a radioactive gaseous waste management system required by 10 CFR Part 50, Section 50.34a, with system operation in accordance with Section 50.36a. The design acceptance criteria for waste gas systems has been given in SRP Section 11.3.

The basic criterion for reactor accidents, including waste gas system failures, is that offsite doses shall not exceed 25 rem to the whole body (10 CFR Part 100). However, that criterion is predicated on the assumption that the probability of occurence is very small. At least since 1972, it has been recognized that the probability of an accidental release from the waste gas system is relatively high and that lower dose criteria are appropriate.

Generally two kinds of waste gas system failures have been designated as warrenting evaluation. These are (1) gross system failures, such as rupture of a decay tank (Regulatory Guide 1.24, Rev. 0, March 1972) or rupture of a line (Regulatory Guide 1.98, For Comment, March 1976) and (2) malfunctions, such as operator errors, valve misalignments, malfunction of attendent equipment and active component failures. Both the probablities and the consequences of a waste gas system leak or failure depend on the kind of accident considered and the characteristics of the system (Regulatory Guide 1.70 Section 15.7.1, Rev. 3, November 1978).

Waste gas systems characteristics differ between plants, particularly between BWRs and PWRs, but for present purposes the most important difference is between those systems designed to withstand the effects of a hydrogen explosion and earthquakes (Regulatory Guide 1.143) and those systems not so designed. Gross failure of the system is considered much less likely if the system is designed to withstand explosions and earthquakes. Accordingly, higher dose criteria have been considered appropriate for evaluating gross failure of these fortified systems. Initially, a 5-rem criterion was used, but more recently the value has been 2.5 rem. For systems not designed to withstand explosions and earthquakes, the criterion has been 0.5 rem.

This dichotomy had led to a problem in that system malfunctions appear to be the controlling failure mode and resistance to explosions and earthquakes provide no protection against operator error and system malfunction. No system-malfunction type failures have been designated as representative. However, it appears that an event, such as valve misalignment or overpressure could give a release approximating that from the rupture of a tank or pipe. Therefore, it was considered that for future safety evaluations the waste gas system failures analyzed could be limited to tank or pipe ruptures but that the dose criterion in every case should be 0.5 rem at the exclusion boundary.

The purpose of this BTP is to provide guidelines on postulated radioactive releases due to a radioactive waste gas system leak or failure. The goal is to minimize potential radiation exposures to workers and the public, and to provide reasonable assurance that the radiological consequences of a single failure of an active component in the waste gas system would not result in exceeding the guidelines of 10 CFR Part 20 for a unique unplanned release and would, therefore, be substantially below the guidelines of 10 CFR Part 100 for a postulated event.

The criteria in Section B, below, provide adequate and acceptable design solutions for the concerns outlined above. This position paper sets forth minimum branch requirements and is not intended to prohibit the implementation of more rigorous design codes, standards, or quality assurance measures than those indicated nor reevaluate waste gas systems with limiting conditions for operation based on more conservative calculational assumptions.

B. BRANCH TECHNICAL POSITION

I. Waste Gas System Leak or Failure Analysis

a) Criteria: The safety analysis report (Section 15.7.1) should provide an analysis of the radiological consequences of a single failure of an active component in the waste gas system. The analysis should provide reasonable assurance that in the event of a unique unplanned release of radioactive gas from the waste gas system, the resulting total body exposure to an individual at the nearest exclusion area boundary will not exceed 0.5 rem. This is consistent with the guidelines of 10 CFR Part 20 and is substantially below the guidelines of 10 CFR Part 100. The bases for the analysis should include the assumption that the waste gas system fails to meet its design intent as required by 10 CFR Part 50, Section 50.34a(c), and Appendix A, GDC 60.

b) Source Term: The safety analysis on the radiological consequences of a single failure of an active component in the waste gas system should use a system design basis source term for light-water-cooled nuclear power plants. The NRC staff method of calculation for this analysis is based on a conservative assumption that the waste gas system maximum design capacity source term (sustained power operation) is 7 times greater than the source term considered for normal operation, including anticipated operational occurrences, as given in SRP Section 11.1. This assumption is in good agreement with previous design basis analysis which used:

1) For a PWR: 1% of the operating fission product inventory in the core being released to the primary coolant, or

2) For a BWR: A fission product release rate consistent with the noble gas release to the reactor coolant of 100 μCi/sec/MWt (after 30 min. decay).

The analysis should assume principle parameters and conditions typical of the equipment designed to remove radioactive gases from the coolant and process and treat these gases during normal operation, including anticipated operational occurrences by the waste gas system. The NRC staff considers that there would be no major alteration in the use or performance of gas separation, reduction, and decay equipment prior to and immediately following this unique unplanned release affected by the waste gas system maximum design capacity source term.

c) Release: The safety analysis on the radiological consequences of a single failure of an active component in the waste gas system involves a release method having the condequence of being a unique unplanned release. Such releases are less frequent than those considered by anticipated operational occurrences and cannot be included in a meaningful annual average for routine releases applicable to plant effluents in 10 CFR Part 50, Appendix I. At the same time, the radiological impact due to such a unique unplanned release has the characteristics of an accident and is important to the health and safety of workers and the public. Waste gas systems designed to acceptance criteria of SRP Section 11.3 have low probability of passive failure, excluding events required by the guidelines of 10 CFR Part 100. All principal release points are to be monitored and controlled according to the requirements of 10 CFR Part 50, Appendix A, GDC 60 and 64, and SRP Section 11.5 provides the acceptance criteria for release point instrumentation to assure that setpoints are established on gaseous effluent lines prior to exceeding the limits of 10 CFR Part 20.

Therefore, the most credible unique unplanned release would be a major leak or a single active failure of a waste gas system component releasing gas by a pathway not normally used for planned releases and requiring a reasonable time to detect and take remedial action to terminate the release. The NRC staff considers that the release of a compressed gas storage tank of a batch-type waste gas system or the inadvertent bypass of the main decay portion of a continuous-type waste gas system (such as charcoal delay beds in a BWR augmented off-gas system) would provide a conservative assumption for any unique unplanned release while the input to the waste gas system is at the system design basis source term. Only the radioactive noble gases (Xe, Kr, Ar) are to be considered since the assumed transit time is great enough to permit major radioactive decay of oxygen and nitrogen isotopes. Particulates and radioiodines are assumed to be removed by pretreatment, gas separation, and intermediate radwaste treatment equipment. The release should be assumed to occur within the building structure housing the waste gas system storage tank or main decay position of the system, and be released to the environs without continuous effluent radiation monitoring to automatically isolate and/or terminate the release. Ground-level release without credit for a building wake factor should be assumed, and a conservative (5%) short-term diffusion estimate for the value $(\overline{\chi/Q})$ determined by a method outlined in the acceptance criteria in SRP Section 2.3.4. No deposition is assumed to occur during downwind transport.

II. Staff Method for Analysis

a) Pressurized Storage Tanks: The safety analysis for the radiological consequences of a single failure of an active component in a waste gas system with compressed gas storage (holdup or decay) tanks or cover gas tanks assumes that the tank being filled has a major leak to the environs. The radioactive noble gas inventory in the tank, at 100% capacity, should be determined based on the system design capacity source term using the parameters and principal components considered for pretreatment and collection of waste gas to the waste gas system tanks during normal operation, including anticipated operational occurrences.

To determine the pressurized storage tank noble gas inventory, the staff method of calculation alters the PWR-GALE Code (NUREG-0017) and requires manual calculations to determine the radiological impact.

1) Enter a value of zero for the "Holdup Time, in days, for Xe."

2) Enter a value of zero for the "Holdup Time, in days, for Kr."

3) Check the value entered for "Fill Time, in days." This should be the average volume for all storage or cover gas tanks. If this is a cover gas system, calculate the effective fill time based on 20% of the liquid tank volumes. (Charcoal delay systems are not applicable.) The PWR-GALE Code limits the minimum fill time to 0.01 days.

4) Rerun the computer program for this analysis only.

5) Multiply each noble gas printout given under "Gas Stripping - Continuous" by 7 to account for the design capacity source term correction.

6) Divide the values in step 5 above by the number of tanks filled per year (equal to 365/value in step 3 above). This gives to tank inventory A_i for each nuclide.

7) Calculate the radiological impact by the following equation:

$$\text{Dose (mrem)} = \Sigma K_i A_i \ (\overline{\chi/Q})(10^{12} \text{ pCi/Ci})/3.15\text{x}10^{7} \text{ sec/year}$$

where,

A_i = The noble gas nuclide activity determined in step 6 above, in curies/event.

K_i = The total-body dose factor given as DFB_i in Table B-1 of Regulatory Guide 1.109, in mrem-m^3/pCi/yr.

$(\overline{\chi/Q})$ = The relative concentration at the nearest exclusion boundary given in Figure 1 of Regulatory Guide 1.24 for ground-level releases, in sec/m^3.

8) The sum dose shall be less than 500 mrem. Using the same parameters, the technical specifications will set a curie limit on a tank, based on the maximum of 500 mrem at the nearest exclusion boundary and using the same noble gas mixture.

b) Charcoal Delay Units: The safety analysis for the radiological consequences of a single failure of an active component in a waste gas system with charcoal delay units assumes that the charcoal unit is bypassed with a 1-hour release to the environs. The staff considers that either a line bypass valve malfunction, control error, or bed bypass would require the remedial action by isolation, and that starting an alternate charcoal unit, if available, or reducing reactor power could take up to 2 hours. The radioactive noble gas concentration should be determined based on the system design capacity source term using the parameters and principal components considered for pretreatment and collection of waste gas to the waste gas system charcoal delay units during normal operation, including anticipated operational occurrences.

To determine the releases without the charcoal delay unit, the staff method of calculation uses the BWR-GALE Code (NUREG-0016) and requires manual calculations to determine the radiological impact. Alterations to the PWR-GALE Code (NUREG-0017) are also included.

1) Enter a value of 0.02 for the "Holdup Time, in days, for Xe." (BWR or PWR-GALE Code)

2) Enter a value of 0.02 for the "Holdup Time, in days, for Kr." (BWR or PWR-GALE Code)

(This time, about 30 minutes, is considered for gases to travel through the components in the waste gas system via the release point to the nearest exclusion boundary.)

3) Rerun the computer program for this analysis only.

4) Multiply each noble gas printout given under "Air Ejector" by 7 to account for the design capacity source term correction.

5) Add to each noble gas value determined in step 4, above, the applicable value for the nuclide given in the source term for normal operation. This step will account for noble gases which have been delayed in the charcoal unit being released during the event.

6) Calculate the radiological impact by the following equation:

$$\text{Dose (mrem)} = \Sigma K_i Q_i \overline{(\chi/Q)} (10^{12} \text{ pCi/Ci}) (7.25 \times 10^{-12} \text{ yr}^2\text{/event-sec})$$

where,

Q_i = The noble gas nuclide release rate determined in steps 4 and 5, above, in curies/yr rate for 2 hrs.

K_i = The total-body dose factor given as DFB_i in Table B-1 of Regulatory Guide 1.109, in mrem-m³/pCi/yr.

$\overline{(\chi/Q)}$ = The relative concentration at the nearest exclusion boundary given in Figure 1 of Regulatory Guide 1.24 for ground-level releases, in sec/m³

7) The sum dose shall be less than 500 mrem. Using the same parameters, the technical specifications will set a maximum release rate to the waste gas system of 100 µCi/sec/MWt (after 30 min. decay) or use the value of Q_i (in µCi/sec) determined above, whichever is less, to assure that the BTP criteria of 500 mrem individual exposure for 2 hrs at the nearest exclusion boundary is met.